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FILED ELECTRONICALLY

November 28, 2001

Ms. Magalie R. Salas
Secretary
Federal Communications Commission
TW-A325
445 12th Street, SW
Washington, DC 20554

Re: ET Docket No. 98-153, *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*
Written *Ex Parte* Presentation of the Intelligent Transportation Society of America

Dear Ms. Salas:

The Intelligent Transportation Society of America ("ITS America") notes that, in ET Docket No. 98-153,[1] the Commission is considering authorization of new "ultra-wideband" ("UWB") uses and technologies within a wide swath of spectrum that includes the 5 GHz frequencies that the Commission recently allocated on a primary basis to the mobile service for use by Dedicated Short Range Communications ("DSRC") devices. Such devices are intended to increase the safety and efficiency of surface transportation, such as automobiles, trucks, buses and trains.[2] The Commission identified and endorsed

[1] *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems,* Notice of Proposed Rule Making, ET Docket No. 98-153 (FCC 00-163, released May 11, 2000) (*"Notice")*.

[2] *Amendment of Parts 2 and 90 of the Commission's Rules to Allocate the 5.850-5.925 GHz Band to the Mobile Service for Dedicated Short Range Communications of Intelligent Transportation Services, ET Docket No. 98-95*, Report and Order, FCC 99-305 (released Oct. 22, 1999).

DSRC use of this spectrum at the specific statutory direction of Congress, and on August 24, 2001, the DSRC industry voted to adopt a specific technical standard to use on this spectrum.

Given the potential for harmful interference between UWB devices and DSRC equipment, ITS America undertook a preliminary technical analysis of the potential for interference between UWB and DSRC, and concurred with its findings. As explained below, our conclusion is that the potential for interference is significant. ITS America therefore submits these comments to the Commission concerning the technical aspects of the proposals made in the UWB proceeding insofar as they would affect the planned uses of the DSRC 5.9 GHz allocation. We request that this letter be accepted as a late-filed written *ex parte* comment pursuant to Section 1.3 of the Commission's Rules.[3] Considering this information would serve the public interest in a complete record and ensure that the latest information with regard to planned DSRC operations in the 5.9 GHz band is available to the Commission for its full consideration in this proceeding.

INTRODUCTION

ITS America is dedicated to improving the efficiency and safety of surface transportation systems, particularly our nation's roads and railroads; and also serves as a utilized Federal Advisory Committee to the U.S. Department of Transportation ("DOT") with regard to matters related to using the spectrum for these purposes. The applications being developed for DSRC services span a wide range, from traffic control, emergency vehicle signal preemption, accident management and driver advisories, to commercial vehicle electronic clearance and intersection collision warning systems.[4]

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[3] 47 C.F.R. § 1.3 (2000).

[4] The Commission set forth a list of DSRC applications at Appendix B of its Report and Order in ET Docket No. 98-95, *supra* note 2.

In response to specific statutory direction from Congress[5] in late 1999, the Commission allocated the 5.850-5.925 GHz band to the mobile service on a primary basis for DSRC to support improvements to the safety and efficiency of our national transportation system.[6] Subsequently the Commission initiated consideration of the technical, service, and licensing rules to govern use of this new DSRC band.[7]

However, in ET Docket No. 98-153, the Commission is considering the authorization of new "ultra wideband" ("UWB") uses and technologies that would utilize a wide swath of spectrum, possibly including the 5.850-5.925 GHz band that the FCC so recently allocated on a primary basis for DSRC. Concerned that such use by UWB devices could conflict with the safety and efficiency uses identified and endorsed by the Commission at the specific statutory direction of Congress, ITS America reviewed existing papers on the subject to inform the preliminary technical analysis described below.

BACKGROUND

In this submission ITS America addresses the effect of UWB devices on the allocation of 5.9 GHz spectrum that the Commission made for the purpose of improving the safety of transportation in the United States. These preliminary technical analyses lead to our conclusion that an unacceptable probability exists that UWB devices

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[5] The *Intermodal Surface Transportation Efficiency Act of 1991* ("ISTEA") established within the U.S. Department of Transportation a national program to develop Intelligent Transportation Systems ("ITS") within the United States. *See* Pub. L. No. 102-240, 105 Stat. 1914 (1991). Following up in 1998 in the *Transportation Equity Act for the 21st Century*, Congress required the Commission, in consultation with the Department of Commerce, to complete a rulemaking on the spectrum needs for ITS, specifically including spectrum for a dedicated DSRC short-range vehicle-to-wayside standard. *See* Pub. L. 105-178, §5206(f) (1998).

[6] *Supra* note 2.

[7] *Wireless Telecommunications Bureau Seeks Comments Regarding Intelligent Transportation System Applications Using Dedicated Short Range Communications, WT Docket No. 01-90* (DA No. 01-686, March 22, 2001; DA No. 00-1047, April 24, 2001).

operating in the DSRC band and used for broadband data transfers, as proposed in the Commission's *Notice,* likely would cause harmful interference to intelligent vehicle devices. An overlay of UWB devices within the 5.9 GHz band for unrelated communications network links that are continually operating, or otherwise used with a high duty cycle, likely would interfere with DSRC devices intended to greatly improve the safety of ground transportation systems on our roads and rail lines.

In the UWB proceeding record, the National Telecommunications and Information Administration ("NTIA"), representing U.S. Government users, coupled with a number private parties, expressed concern with UWB operations at the proposed power levels on frequencies between 1 and 6 GHz.[8] Technical studies submitted by these parties explain and support requests to confine operation to frequencies below 1 GHz and/or above 6 GHz. Excluding UWB devices intended for communications network purposes from the 1-6 GHz range would eliminate their detrimental effects upon DSRC systems, and we therefore join in requesting that in the microwave bands UWB be authorized only above 6 GHz, if at all.

The record before the Commission in this proceeding amply demonstrates that it would be premature for the Commission to authorize UWB devices in the 5.9 GHz band for purposes of what could be almost continuous broadband communications links. Analysis of the proposed UWB rules reveals that permitting UWB emissions for broadband networks to overlay those of the DSRC devices for which the band is allocated will create the potential for unacceptable levels of interference and thereby could

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[8] U.S. Department of Commerce, National Telecommunications and Information Administration, *Assessment of Compatibility Between Ultrawideband Devices and Selected Federal Systems,* NTIA Special Publication 01-43 (January, 2001). *See also, e.g.,* Cingular Wireless, *Ex Parte* Submission in ET Docket No. 98-153 dated Oct. 12, 2001.

substantially undermine the public safety goals of the DSRC allocation. In certain applications UWB and DSRC devices are likely to be operated in relatively close proximity to each other and the interference is directly related to the proximity of the devices, as discussed below. In addition, there appears to be various types of UWB devices planned with modulation types that have not been decided upon, and therefore not tested for their interference potential. Finally, the aggregate effects of multiple UWB devices expected to be within close proximity to each other and to DSRC devices exacerbates the potential for harmful interference.

Therefore, at a minimum, if the Commission is not ready on this record to restrict UWB devices to 6 GHz and above, it should issue a *Further Notice of Proposed Rule Making* to collect the information that is essential to evaluate the interference potential of UWB devices to DSRC (and other communications devices) using the various intended types of modulation that are meant to operate continually to provide high data-rate communications network links on the same frequencies that DSRC devices are intended to operate. We note that efforts also are underway in the international telecommunications community to assess the impact of UWB devices.[9] Only with such additional study and analysis will the Commission have the information necessary to formulate the technical requirements necessary to ensure safe and interference-free operation of both the DSRC and UWB-based services, whether together within the same bands if feasible, or in separate bands if not feasible.

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[9] *See Noise Level of Radiated Emissions From Multiple Ultra Wideband (UWB) Transmitters,* Delayed Contribution Document 8A/91-E / Document 8B/151-E, submitted by Canada to the International Telecommunication Union (ITU) Radiocommunication Bureau Working Parties 8A and 8B dated October 16, 2001. A copy of this document is attached at Appendix B.

DISCUSSION

Allocation of the 5.9 GHz band for Intelligent Vehicle Use. When the Commission allocated the DSRC band to mobile services for the use of DSRC, it deferred to a later proceeding its consideration and adoption of licensing and service rules. Subsequently, industry and the DOT promptly engaged in designing test procedures and carrying out tests of proposed standards that would be appropriate for transportation uses at the 5.9 GHz frequency range. Evaluation of the competing proposed standards was accomplished by performance testing sponsored by the Federal Highway Administration and performed by the DSRC 5.9 GHz Standards Writing Group, a sub-group of the American Society for Testing and Materials (ASTM) E17.51.[10] After rigorous testing, on August 24, 2001, the standards group endorsed a transmission standard derived from the IEEE 802.11a standard, which is an OFDM-based standard currently used in the 5 GHz U-NII spectrum.

Impact of UWB operations on DSRC communications. After the 5.9 GHz spectrum allocation was completed, the modulation scheme selected, and the process of promulgating technical and service rules for the 5 GHz DSRC band under way, the Commission is considering authorization of UWB devices that are likely to impact the operation of DSRC devices envisaged in the Commission's earlier *Report and Order* and by Congress in directing the Commission to conclude the allocation proceeding. Because some UWB and DSRC devices are planned for purposes that make it likely that they will be closely located, or even co-located, the preliminary analysis indicates that it will be very difficult for UWB broadband communications devices to co-exist with DSRC applications within the same 5.9 GHz band. It is likely that DSRC uses and the public

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[10] ASTM is the ANSI–accredited standard developer focused on promoting public health and safety, the reliability of materials and services, and facilitating commerce.

that will rely on DSRC applications would be subjected to harmful interference between the devices.

As ITS America noted in its previous reports to the Commission, many of the candidate DSRC applications, including but not limited to in-vehicle messaging and signing, intersection collision avoidance systems, and electronic toll collection will be used to protect the safety of life, health and property of its users.[11] DSRC operations therefore are deserving of careful consideration and technical protection. It is essential that adequate protection from UWB interference be accorded DSRC operations.

Preliminary Technical Analysis of UWB Impact Upon 5.9 GHz DSRC Spectrum. To determine the validity of our initial concerns, the potential impact of UWB devices upon DSRC operations based upon commonly–accepted theoretical technical methods was analyzed. Appendix A to this letter is a spreadsheet summarizing the results.

Based upon our knowledge of prospective UWB device technical operating parameters as proposed by the Commission in its *Notice of Proposed Rulemaking,* as well as the DSRC specifications, the range at which a UWB transmitter operating in the 5.9 GHz range is likely to interfere with a 5.9 GHz DSRC receiver was calculated. In practice, there is a high degree of probability that this analysis will apply equally to all radio receivers so long as the characteristics of the UWB signal are consistent with those

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[11] *See* Intelligent Transportation Society of America, *Status Report on Industry Discussions on Licensing and Service Issues and Deployment Strategies for DSRC-Based Intelligent Transportation Systems Services in the 5.850-5.925 GHz Band,* WT Docket No. 01-90 (submitted October 6, 2000) at p.35; *see also Comments of the Intelligent Transportation Society of America,* Docket 01-90, filed May 16, 2001.

considered to be noise-like and very wide band.[12] These calculations are based on power spectral density analysis.

First, the signal level arriving at an antenna that will interfere with reception of the 5.9 GHz signal was calculated. Interference will occur when the interfering signal is at a level equivalent to the noise floor of the receiver. The sensitivity and range of the receiver will be degraded for the desired signals whenever the interfering signal is greater than the receiver noise floor.

The noise floor of the receiver was calculated using standard methodology: adding the noise floor (denoted as variable *Rx NF*) to the 50 Ohm noise floor assumed for a temperature of 290 Kelvin (~ 63 degrees Fahrenheit). The noise floor is comprised of white noise exhibiting equal power at all frequencies. The noise floor therefore can be expressed as a power spectral density, or the amount of power within a specific bandwidth. The spreadsheet includes the power per 1 Hz, 1 MHz, and 20 MHz.

Having established the level at which UWB signals at a DSRC receiver would cause harmful interference to the desired signals, the distance that a UWB transmitter would have to be from the receiver in order to prevent harmful interference was then calculated for UWB power levels. The equation for this calculation is:

UWB transmit power - path loss < interference level.

The path loss model utilized is the standard path loss model:

Path loss = (c/(4*PI*f*d))^x ; where:
c = speed of light (meters/sec)
f = carrier frequency (5.9GHz in this case)
d = distance in meters

[12] To the extent that the Commission may authorize UWB devices in the 5.9 GHz frequency range, it will be essential to prevent long strings of unchanging bits in order to avoid the interference mechanism correctly identified by the Commission, that a steady string of the same bits could result in a signal becoming a set of spectral lines with quite different interference potential than the noise-like spectrum that our analysis assumes would be produced under normal modulation. *See Notice*, *supra* Note 1 at ¶ 37.

x = path loss exponent: 2 for free space, higher for obstructed environments.

When the log is expressed in decibels, the equation becomes:

path loss (dB) = loss at 1 meter (dB) + x*10*log(distance)

(The loss at 1 meter depends upon the carrier frequency, and is calculated to be 47.9dB at 5.9 GHz.)

As the path loss exponent x increases, the loss also increases and this will permit UWB devices to use more power at a given distance before harmful interference results. However, for the very short ranges likely to be found between envisioned DSRC and UWB devices commonly there may be no obstructions between a UWB transmitter and the DSRC receiver. Therefore, an exponent of 2 is appropriate.

Finally, consistent with the Commission's *Notice,* the UWB transmit power is expressed in dBs relative to the limits provided under the Commission's current Part 15 rules, 47 C.F.R. § 15.209. The Section 15.209 power limit is expressed as Effective Isotropic Radiated Power ("EIRP"), therefore it includes the effect of any antenna gain at the transmitter and is equivalent to -41dBm/MHz EIRP. In the table, the range in meters at which harmful interference would occur to a DSRC receiver is provided.

The results of this theoretical analysis are confirmed by their consistency with the practical results published by the NTIA in its report on compatibility between UWB and GPS.[13] Since commercial UWB enterprises expect their communications products to have a useful range of approximately 10 meters,[14] a significant reduction in EIRP would not sufficiently reduce the harmful interference to DSRC receivers of the close-range UWB transmitters contemplated under the *Notice*.

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[13] U.S. Department of Commerce, National Telecommunications and Information Administration, *Assessment of Compatibility Between Ultrawideband (UWB) Systems and Global Positioning System (GPS) Receivers,* NTIA Special Publication 01-45 (February, 2001).

Given the amount of harmful interference that would be caused by UWB devices if the proposed rules were promulgated, not surprisingly at least one commercial UWB enterprise agreed that it "will not object to emissions limits in the GPS band ... of 35 dB below Section 15.209(a) levels...."[15] Nonetheless, given the lack of available data confirming that overlay of UWB signals will not interfere with DSRC receivers operating at 5.9 GHz, which are expected to be widely deployed (as well as numerous other devices in allocated bands from 1- 6 GHz), our analysis indicates that an UWB overlay even at a 35dB reduced power level would be insufficiently controlled. We therefore respectfully request the Commission to recognize that commercial UWB emissions in the 1-6 GHz spectrum range, and in particular the DSRC band, are unacceptable; and that if the Commission does conclude that it should authorize this technology, at a minimum it should issue a *Further Notice Proposed Rule Making* to gather the appropriate data with which to fashion technical rules that would ensure safe and interference-free operation of UWB-based services.

Other Analyses of UWB Impact. As noted above, the NTIA has conducted two analyses of UWB impact, both of which indicate that substantial interference issues exist.[16] In addition, after studying the matter, in a submission to the ITU Radiocommunication Bureau Working Parties 8A and 8B Canada stated that "results indicate that the proliferation (uncontrolled mass usage) of UWB devices could considerably raise the RF noise floor leading to a harmful interference level that spreads over very large frequency range and could impact many licensed radiocommunication

[14] XtremeSpectrum Letter to The Honorable Donald L. Evans, Norman Y. Mineta, Donald H. Rumsfeld and Daniel S. Golden dated September 17, 2001, and filed in FCC ET Docket No. 98-153.

[15] XtremeSpectrum, *Ex Parte Communication* filed in FCC ET Docket No. 98-153 dated September 10, 2001.

[16] *See* footnotes 8 and 13, *supra*.

services."[17] These studies raise significant technical issues regarding the interference potential of UWB devices that the Commission must study and resolve before taking action that, no matter how well intentioned, could disrupt a number of communications services and imperil the introduction of others that have been authorized.

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[17] *Supra* footnote 9.

CONCLUSION

The potential for harmful interference between UWB and DSRC devices operating within the same 5.9 GHz band is significant. This band was allocated recently on a primary basis for DSRC devices, and industry has concluded testing and selected a basic technical standard for DSRC devices.

Given the national policy to promote design and implementation of DSRC devices for purposes, *inter alia*, of public safety as evidenced by two Congressional statutes and evidence of a substantial likelihood of interference, we respectfully request that the Commission undertake to obtain up-to-date information and analyses through issuance of a *Further Notice of Proposed Rule Making* for communications network or other similar UWB applications intended to have heavy duty cycles and to be located within close proximity to the roads and rail tracks where DSRC devices also will be operating.

Respectfully submitted,

By: /s/ Paul Najarian

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APPENDIX A

Distance at Which UWB Devices Would Interfere with Dedicated Short Range Communications Systems (DSRC) at 5.9 GHz

UWB EIRP (relative to §15.209)	EIRP per Hz	EIRP per MHz	EIRP per 20MHz	EIRP at 5.9GHz	Range at which harmful interference occurs (meters)	UWB equivalent Tx power
0	-101	-41	-28	-3	25.5	20.7
-5	-106	-46	-33	-8	14.4	15.7
-10	-111	-51	-38	-13	8.1	10.7
-15	-116	-56	-43	-18	4.5	5.7
-20	-121	-61	-48	-23	2.6	0.7
-25	-126	-66	-53	-28	1.4	-4.3
-30	-131	-71	-58	-33	0.8	-9.3
-35	-136	-76	-63	-38	0.5	-14.3
-40	-141	-81	-68	-43	0.3	-19.3
-45	-146	-86	-73	-48	0.1	-24.3
-50	-151	-91	-78	-53	0.1	-29.3

Rx NF = 3
Rx antenna gain = 6
loss at 1m = -47.9
path loss exponent = 2

Rx interference level =	per Hz	per MHz	per 20MHz
	-177	-117	-103.9897

UWB coding gain = 24.0

APPENDIX B

INTERNATIONAL TELECOMMUNICATION UNION

RADIOCOMMUNICATION STUDY GROUPS

Delayed Contribution
Document 8A/91-E
Document 8B/151-E
16 October 2001
English only

Received: 16 October 2001

Canada

NOISE LEVEL OF RADIATED EMISSIONS FROM MULTIPLE ULTRA WIDEBAND (UWB) TRANSMITTERS

1 Introduction

Ultra Wideband (UWB) is an emerging technology that operates by sending low power narrow pulses over short distances. Pulses of a width of about a nanosecond or less are modulated (typically PPM) to carry information. UWB emissions spread over a large frequency range that could extend over bands currently allocated to several radiocommunication services. UWB emissions appear to conventional wireless receivers as RF noise. The aggregate effect of these emissions could raise the man-made RF noise floor.

UWB technology can be integrated into many applications to replace wired connections. Manufacturers anticipate that UWB technology will be relatively cost-effective to integrate into commonly used devices at home, office, and other environments. Although other technologies (802.11b and Bluetooth) could be integrated in such applications, UWB may have the potential to support many users at high speed and low cost. For example, UWB wireless personal networks can be established at home allowing televisions, VCRs, stereo-systems, and computers to communicate with each other without using cable connections. Similarly in a typical office environment, UWB wireless can replace wired connections to the monitor, keyboard, mouse, speakers, printers, and to the local area network. Another projected large use of UWB applications is in tagging systems, ID cards, license plates, and any asset or equipment that needs to be tracked. Thus in a highly populated area, there could be an average density of several UWB devices per square meter.

During the WP 8B meeting of October 2000, ICAO proposed (8B/13-E) a new Study Question concerning the protection of aeronautical safety-of-life services operating in the range 1 – 6 GHz from interference that can be caused by UWB devices. WP 8B expressed the opinion that a broader attention to the introduction of UWB devices might be required than WP 8B, or even Study Group 8, can offer within its terms of reference, since the introduction of UWB devices might affect all radio services. WP 8B has not taken any action on the ICAO proposal but invited WP 1A through a liaison statement (1A/28-E) to review this matter with a view to identifying the need for ITU-R to initiate, through a new Study Question, studies on UWB devices.

This contribution presents a preliminary study on the use of UWB technology at 1.5 GHz. The objective is to assess the aggregate effect of mass usage of low power UWB devices on the man-made RF noise floor and consequently on co-existence of UWB with wireless services. The UWB technology and its applications are first introduced, then the aggregate spectral power flux density (SPFD) is calculated for 3 types of UWB devises: tagging devices, handheld transceivers, and packet radio for low probability interference and detection (LPI/D).

An integral simulation approach is used to calculate the aggregate SPFD versus UWB transmitter density. The simulation results indicate that the proliferation (uncontrolled mass usage) of UWB devices could considerably raise the RF noise floor leading to a harmful interference level that spreads over very large frequency range and could impact many licensed radiocommunication services. Finally, this contribution proposes modification to the ICAO (8B/13-E) draft New Question on UWB to broaden its scope.

Further studies are needed to fully assess regulatory implications as well as effects of radiated emissions from multiple UWB devices on the RF noise floor and consequently on existing radiocommunication services. These studies should provide a better understanding of the impact on the radio spectrum of uncontrolled use of multiple UWB devices and could provide the basis for the development of ITU-R Recommendation(s) on this topic.

2 UWB Applications

UWB technology has some useful characteristics that make it attractive for use in many applications. Among the advantages of UWB technology:

1. Excellent immunity to interference from radiocommunication systems.
2. Low susceptibility to multipath fading. The short pulse lengths resolve the multipath propagation; thus UWB systems are effective in highly cluttered environments.
3. Secured transmissions since UWB emissions appear as noise to conventional radiocommunication systems.
4. High processing gain.
5. UWB devices can transmit at a low spectral power density.
6. System simplicity: no carrier frequency, no linear amplifier, and no Intermediate Frequency (IF) stage.
7. High bandwidth multi-user systems.
8. Adequate for short-range communication.

Among the disadvantages of UWB technology:

1. Requires very accurate timing synchronization.
2. Spreads over very wide frequency range, which may impact radiocommunication services allocated in the affected bands.
3. Depending on the data rate, the transmit power could become comparable to those of some radiocommunication services.
4. Some types of UWB devices transmit at relatively high peak power.
5. Requires special antennas.

Most UWB applications fall into two categories: short range communication systems and radar or position location systems.

Some of short-range voice, data, and control communication applications include:

1. High-speed short-range wireless links such as wireless local area networks and wireless personal area networks.
2. Security movement tracking systems such as electronic fences and proximity alarms.
3. Medical applications such as monitoring heart rate, breathing, and other health functions.
4. Sensors for automobiles such as intelligent highway applications, collision avoidance systems, and remote keyless entry.
5. Manufacturing and industrial robotic controls, etc.
6. Tagging system such as: ID cards, license plates, and any asset or equipment that needs to be tracked.

Some of radar or position location system applications include:

1. Ground penetrating radar to locate objects such as mineral deposits, nonmetallic pipes, plastic land mines, archeological sites, flaws in bridges and highways.
2. Imaging devices to improve safety in the construction and home repair industries.
3. Detection and imaging of objects such as through-wall sensing radar to detect people hidden behind a wall or under debris in situations such as hostage rescues, fires, collapsed buildings, or avalanches.
4. RF identification and tracking systems.
5. Liquid level sensors.

3 Computer Simulations and Results

In this section, the aggregate spectral power flux density is calculated for three types of UWB devices: tagging systems, handheld transceivers, and packet radios for low probability of interference and detection (LPI/D). The used devices are prototypes with the following parameters:

UWB Equipment Type	Center Frequency f_c (MHz)	Bandwidth BW_{tx}(MHz)	Average Spectral Power Density (pW/Hz)
Tagging System	1500	400	0.18
Handheld Transceiver	1500	400	1.60
LPI/D Packet Radio	1500	400	8.00

The following assumptions are also made:

1. Transmit and receive antennas are isotropic with unity gains (0 dBi).
2. The victim receiver is assumed to have a bandwidth BW_{rx} = 400 MHz identical to that of the transmitter. This assumption is adequate to study the impact on the RF noise floor as well as for some radar receivers. However, when the victim receiver has a bandwidth different from that of the transmitter, a correction factor of $10 \log_{10} (BW_{rx} / BW_{tx})$ should be considered.
3. The UWB transmitters are uniformly distributed within a radius of one kilometer around a victim receiver with the receiver is in the center of the distribution.

4. All UWB devices transmit at the same average power and these powers accumulate in the victim receiver.
5. All UWB devices are transmitting are assumed to be in active transmit mode as in busy local area networks. Timing aspects including the duty cycle of the transmitter will_impact the simulation results.
6. Free space propagation loss. Though in the near-field, the free-space model is not accurate.
7. Attenuation by walls and other obstructions is not considered here. Such attenuation will impact the simulation results.

Two approaches could be used to calculate the aggregate spectral power flux density (SPFD) from multiple UWB transmitters: an integral approach and a Fourier Transform approach.

The integral approach assumes a uniform distribution of UWB transmitters (represented by crosses) in a circular area (1 m up to 1 km) around a victim receiver (Rx) as shown in Figure 1.

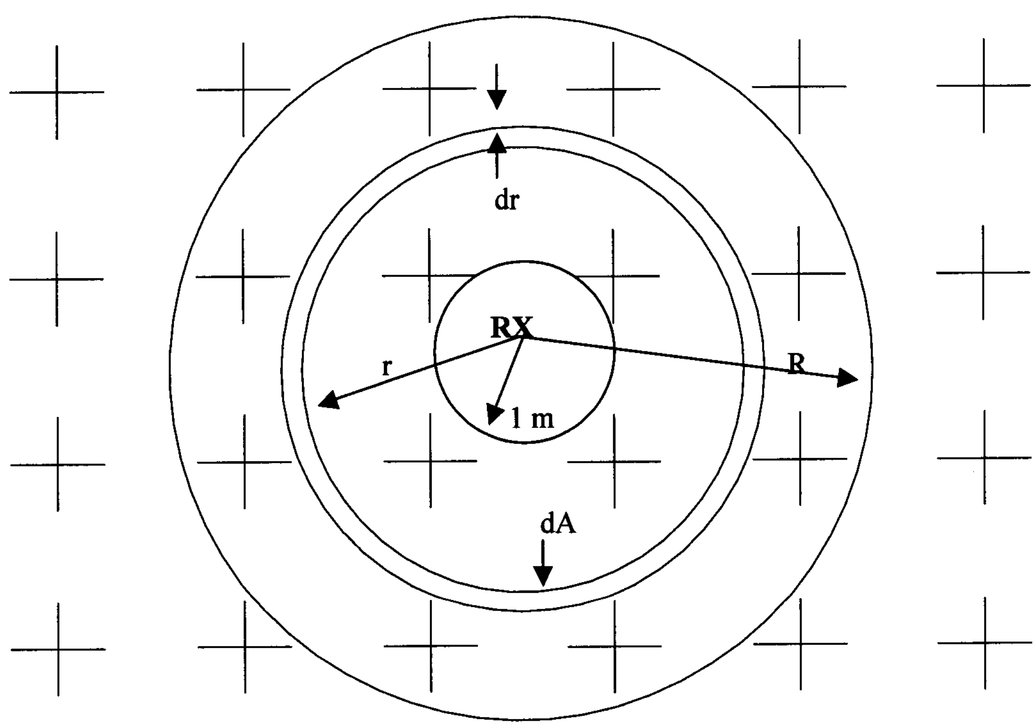

FIGURE 1

The Integral Approach

First, a differential area is identified around the victim receiver, $dA(m^2) = 2\pi r\ dr$, where r (meter) is the distance from the victim receiver. In this area, the total transmitted power is, dP_{tot}(Watts) = $NPG_t\ dA$. Where N (number of UWB devices/m^2) is the UWB transmitter density, P(Watts) is the power delivered to the transmit antenna, and G_t is the antenna gain of the transmitter. The differential power flux density at distance r is, dPFD(Watts/m^2) = dP_{tot} / ($4\pi r^2$) = $NPG_t\, dA / (4\pi r^2)$. For a transmitter bandwidth BW_{tx}(MHz), integrating the dPFD over a range 1 to R meters yields the total spectral power flux density at the victim receiver,

$$\mathrm{SPFD(Watts/m^2/MHz)} = \mathrm{PFD}/BW_{tx} = (NPG_t/2\ BW_{tx}) \ln R.$$

The Fourier Transform approach is based on a paper by Robert B. Marcus (IEEE, International Symposium on Electromagnetic Compatibility, 1990). In this approach, the UWB devices are linearly distributed in a 1 km square with the receiver in the center. The SPFD is calculated for each UWB device using the Fourier Transform of the radiated pulse. For a specified UWB device density, the aggregate SPFD is the sum of the SPFD contributed by each device. The type of transmit antenna influences the shape of the radiated pulse.

Figure 2 shows aggregate spectral power flux density versus the UWB transmitter density / number of transmitters. The integral approach is used to generate these curves. Figure 2 also shows the man-made RF noise floor (4.2453×10^{-12} Watts/m^2/MHz) in a business environment at 1.5 GHz calculated by extrapolation based on ITU-R Recommendation P.372-7.

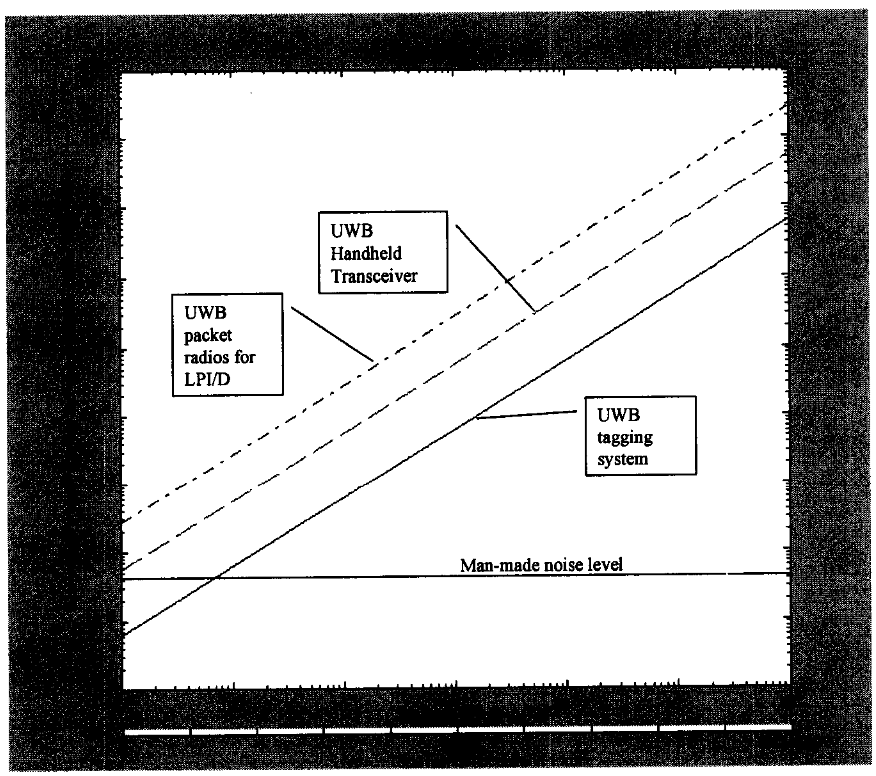

FIGURE 2

Simulation Results

These SPFD curves show that at a low device density of 10^{-5} per m^2 (equivalent to 30) devices per square km), a few UWB tagging devices could operate without raising the noise level above the man-made RF noise floor. This low-density scenario could be met in a rural environment. However, in an urban environment, especially in a business core, it is reasonable to assume at least one device per m^2. At this density, the aggregate SPFD emitted by the UWB devices exceeds the RF noise floor by about 50 dB. Therefore, the use of a large number of UWB transmitters greatly increases the RF noise level resulting in undesirable spectrum pollution that would have a negative impact on the operation of radiocommunication services.

4 Conclusions

In order to evaluate the consequence of permitting the operation of UWB devices on unlicensed basis, administrations are encouraged to study the impact of aggregate noise generated by a large number of UWB devices on frequency bands currently allocated to radiocommunication services.

This contribution presented a preliminary study on the aggregate effect on the RF noise floor of 3 types of UWB devices operating at 1.5 GHz. Similar results are expected when operating at other radio frequencies. Based on the result of this study, the following conclusions can be drawn:

a) UWB technology is a very promising technology that could be integrated into many useful applications. These applications could potentially results in mass usage of UWB devices in all environments (home, office, store, etc.).

b) The aggregate effect of UWB devices could greatly raise the man-made RF noise floor with possible implications of interference to currently licensed radiocommuncation services in the RF bands under consideration.

c) Due to the spreading nature of UWB technology over a large frequency range, the increase in the RF noise level could also lead to harmful interference to radiocommunication services operating in adjacent and nearby frequency bands.

5 Proposal

The Canadian proposal is to:

1. Bring the attention of Administrations to possible implications of interference_of devices using UWB technology (e.g.,_the RF noise floor) on the usability of various frequency bands.

2. Emphasize the need for further ITU-R studies to provide a better understanding of the impact of uncontrolled mass usage of UWB devices on the radio spectrum. These studies should fully assess the implications of radiated emissions from_multiple UWB devices on the RF noise floor and consequently on the usability of the radio spectrum by radiocommunication services. The studies should also specify technical and operational constraints on UWB devices to ensure that harmful interference is not caused to radiocommunication services. These studies could provide the basis for the development of Recommendation(s) on this topic.

3. Modify the draft New Study Question on UWB, proposed during the WP 8B meeting of October 2000 in document 8B/13-E, as shown in Appendix-A1.

APPENDIX-A1

DRAFT NEW QUESTION

QUESTION ITU-R XX-Y/Z

Compatibility between ~~short range communications and radar devices using~~ ultra-wideband (UWB) ~~modulations~~ technology and ~~aeronautical safety-of-life~~ radiocommunication services

(2001)

The ITU Radiocommunication Assembly,

considering

a) that UWB devices are ~~planned to operate~~ being considered for operation across numerous frequency bands ~~in~~ including the range ~~of~~ 1 to 6 GHz;

b) that UWB technology can be integrated into many applications such as short range communication devices and radar imaging ~~devices~~ ~~may offer new~~ capabilities for ~~to~~ public safety, construction, engineering, science, and law enforcement;

c) that these applications could potentially result in mass usage of UWB devices in various environments (home, office, store, industry, public places, etc.) where radiocommunication services may have already been deployed and are in operation;

d) ~~c)~~ that typical emissions from UWB devices, are at a low average power;

~~d) that the potential for interference from UWB to aeronautical safety-of-life services services, has not yet been adequately addressed;~~

e) that some UWB devices may transmit at relatively high peak power levels;

f) ~~e)~~ that the aggregate effects of interference from a large numbers of UWB devices on the existing electromagnetic environment has not been fully studied;

g) ~~f)~~ that the spectrum requirements for UWB devices vary according to operational usage;

h) ~~g)~~ that UWB devices might be considered for unlicensed operations without protection from ~~other~~ ~~telecommunication~~ radiocommunication services;

j) that many existing and proposed radiocommunications services including aeronautical safety-of-life, radiolocation, radionavigation, mobile communications, and radio astronomy services are very sensitive to the man-made radio noise level and could be affected by UWB usage.

decides that the following Question should be studied

1 What are necessary conditions to assure that UWB devices will not cause harmful interference to radiocommunication services?

2 What is the aggregate effect of interference from a large number of UWB devices on the existing electromagnetic environment and consequently on sharing with radiocommunication services?

~~1 What power levels and other technical criteria (for example, peak power, peak-to-average power, pulse repetition frequency, dithering of the signal, pulse width) could be allowed for UWB devices to ensure that harmful interference is not caused to telecommunication services, particularly safety services, such as aeronautical radionavigation?~~

~~2 What are the spectrum requirements that could be used to support UWB devices that may allow global access and application?~~

~~3 What operating parameters are proposed and what is the mechanism for interference to other services?~~

~~4 What measures are required to secure a reliable operation of UWB considering the electromagnetic environment for which they are proposed? What UWB characteristics are necessary to ensure operations in the existing environment?~~

~~5 What categories of applications can be identified for these devices and what should their allocation be?~~

further decides

1 that the results of the ~~above~~ studies <u>outlined above</u> should be included in (a) Recommendation(s);

2 that the ~~above~~ studies <u>outlined above</u> should be completed by December ~~2001~~ <u>2003</u>.

<u>*Note*: Proposed category S2.</u>